GE
Intelligent Platforms

Programmable Control Products

VersaSafe

Integration Guide, GFK-2735

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1 *Introduction*

1.1 Scope

This document describes how to integrate a VersaSafe machine safety project into a PACSystems (RX3i) based automation application, using Proficy Machine Edition.

Creating the safety project itself, as well as any safety related assessments, is not within the scope of this document.

This document consists of two parts: part one (chapters 3 to 6) provides help for a quick start: install hardware, configure fieldbus, GE IP Controller and HMI and operate HMI.

The second part contains reference information for GE IP Controller programmers and HMI designers.

1.2 References

VersaSafe VersaPoint Module, IC220SDL543 User's Manual, GFK-2730

VersaSafe VersaPoint Module, IC220SDL953 User's Manual, GFK-2731

VersaSafe VersaPoint Module, IC220SDL753 User's Manual, GFK-2732

VersaSafe VersaPoint Module, IC220SDL752 User's Manual, GFK-2733

VersaSafe VersaPoint Module, IC220SDL840 User's Manual, GFK-2734

2 Overview

2.1 What is VersaSafe

VersaSafe is a configurable machine safety solution, designed for mid sized machine safety applications in the range of approximately 32-128 safety IO.

VersaSafe is based on VersaPoint Network Interface Units (NIUs). For the first step, VersaSafe will support Profibus. Other NIUs will follow step by step.

2.2 VersaSafe Integration Overview

VersaSafe needs a GE IP Controller application logic and a fieldbus to perform communication between main GE IP Controller and VersaSafe modules, as well as for communication between the safety modules amongst each other. This is referred to also as host environment.

There is no safety related requirement, neither to application logic nor to fieldbus.

However the host environment must provide a cyclic, deterministic and device-consistent communication. Generally, any host environment, which is supported by a VersaPoint NIU and which is compliant to above requirements is able to run VersaSafe.

This integration guide describes how to integrate VersaSafe into an RX3i/QuickPanel View/Control host environment.

Steps to integrate VersaSafe into a PME/RX3i/QuickPanel View/Control project

- Import the VersaSafe integration drawer into Machine Edition
- Drag UDTs and logic blocks from the integration drawer into the RX3i logic, import the csv variable file(s)
- Drag the screens and scripts from the integration drawer into a PME View target, and import the csv variable file(s) and the language grid.
- Import an XML file into the RX3i logic, which was previously created by VersaConf Safety for each safety island
- Configure GE IP Controller logic for all individual safety islands

2.3 Preconditions

2.3.1 Software Requirements

- Proficy Machine Edition, LD PLC and View, V 7.0 SIM 7 or higher
- VersaConf Safety configurator V 2.7 or higher
- VersaSafe Integration Package: PME drawer, auxiliary files, this manual

2.3.2 Hardware Requirements

- RX3i controller with Ethernet and Profibus Master
- Profibus NIU with VersaSafe modules
- QuickPanel View/Control

3 Hardware Installation – Quickstart

This chapter shows only some fundamental steps for a quick start. For more information refer to the appropriate hardware manuals.

VersaSafe modules can be installed at any VersaPoint NIU, combined with standard VersaPoint modules. For currently supported field busses see fieldbus configuration.

3.1 DIP Switch setting

Each VersaSafe module must be configured by DIP switch for the correct island- and satellite number. DIP switches are only visible and operable if the module is not installed. Make sure switches are set correctly before you install the module.

DIP switch	LPSDO	PSDx
0-2	always 0	Satellite number 1 … 5
3-7	Island number 1 … 31	Island number 1 … 31
8	always off	always off
9	off : normal mode on : multiplexer mode	always off
Mode	1 : 16 Words IO, max 3 satellites 2 : 24 Words IO, max 5 satellites	Mode 2
Baud rate	500KBD	500KBD

Note that multiplexer mode is not explicitly supported by this package. However you can use multiplexer mode with some simple GE IP Controller logic. Refer to hardware manuals for more information about multiplexer mode.

4 Fieldbus Configuration

4.1 Profibus

A PBM300 Profibus master must exist in the RX3i hardware configuration. Add as many NIUs (IC220PBI002) as your application requires. Add standard and safety modules to the NIUs. The distribution of safety modules is completely free. Safety modules of the same island can be located at the same or at different NIUs. Safety modules of different islands can be located at the same NIU or at different NIUs.

Note that the one LPSDO requires 16 or 24 words of data. This may restrict the number of usable LPSDOs for one NIU due to system limitations.

Double click on the modules to review and alter the assigned addresses. It is recommended to create a scheme for addressing. For example you may reserve %AI101 to %AI199 for safety island number 1 and the same for %AQ.

Then the first 24 Words (101-124) are for the LPSDO. Always reserve 24 Words, even in case of a 16 Word / 3 satellites configuration. Then address 125 to 128 is for satellite 1, address 129 to 132 is satellite 2 and so on.

Use the same scheme for island two with addresses 201 upward, see table below.

Example:

Island	LPSDO (0)	Sat. 1	Sat. 2	Sat. 3	Sat. 4	Sat. 5
1	101-124	125-128	129-132	133-136	137-140	141-144
2	201-224	225-228	229-232	233-236	237-240	241-244
3	301-324	325-328	329-332	333-336	337-340	341-344
4	401-424	425-428	429-432	433-436	437-440	441-444

You will need these addresses to complete the software configuration later.

A csv file with variables using the above scheme for island 1 to 4 is provided for convenience.

5 *Detailed Software Integration Steps*

The integration package includes at least the following files:

File	Contents
VersaSafe_Vxxx.zip	Start-up PME project.
VersaSafe Integration.zdrw	PME drawer
PH_VSafe_xx.csv	variables to import in the GE IP Controller target
VS_1.csv, VS_2.csv, VS_3.csv, VS_4.csv	variables to import in the GE IP Controller target
H_VSafe.csv	variables to import in the HMI target
VS_Language.csv	Language grid entries

Additional files to speed-up integration might be present.

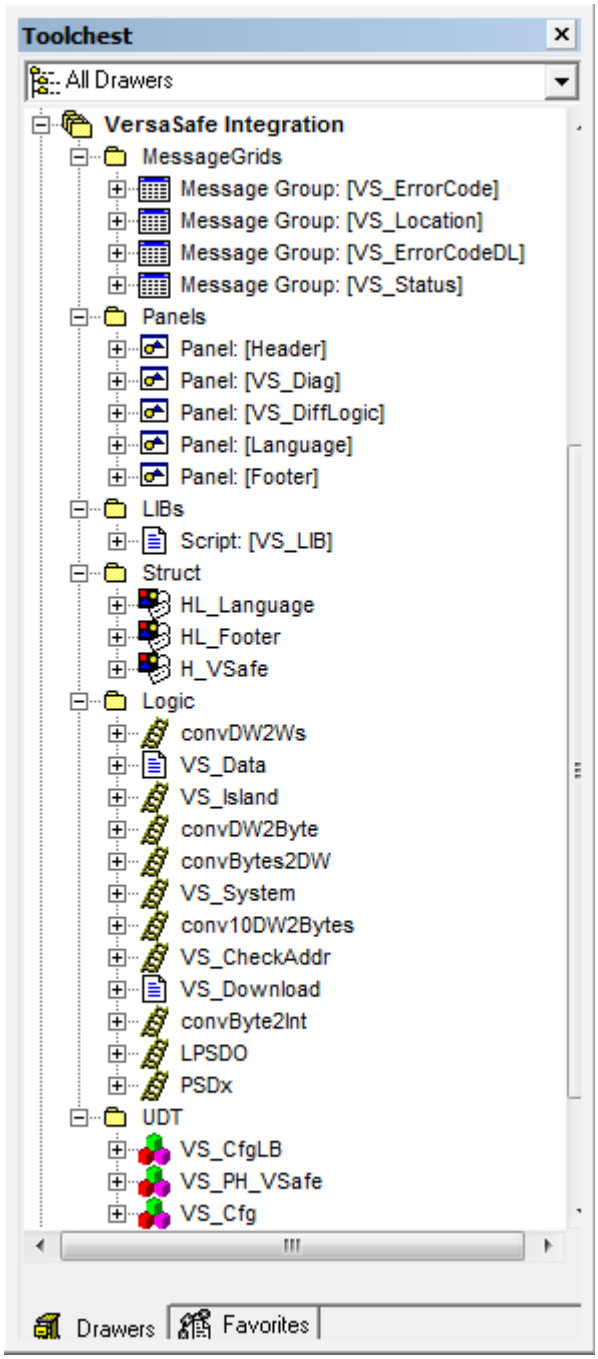
You can use any existing PME RX3i/QuickPanel View/Control project to integrate VersaSafe or you can start a new project or you can use the start-up project. The RX3i target and the QuickPanel View/Control target might be in same project or in different projects. For the steps in the next chapters it is assumed we have already an RX3i target in a PME project and a 12” QuickPanel View/Control target within the same or in different project.

The following steps describe how to add VersaSafe to an existing project.

Open the common (or the RX3i) project and proceed as described below:

5.1 Import VersaSafe integration Drawer

Locate the file VersaSafe Integration.zdrw and import it into the PME toolchest.



5.2 Import UDTs, Logic Blocks, and Variables

Open the drawer “VersaSafe Integration” in the toolchest window.

1. Drag all items from the UDT folder to the UDT folder of the RX3i target.
2. In the RX3i target’s “Program Blocks” folder add a folder “VersaSafe”
3. Drag all logic blocks from the toolchest Logic folder to the VersaSafe folder. Start with conv… blocks and then add VS_Data, VS_CheckAddr, VS_Download, VS_Island and then VS_System.

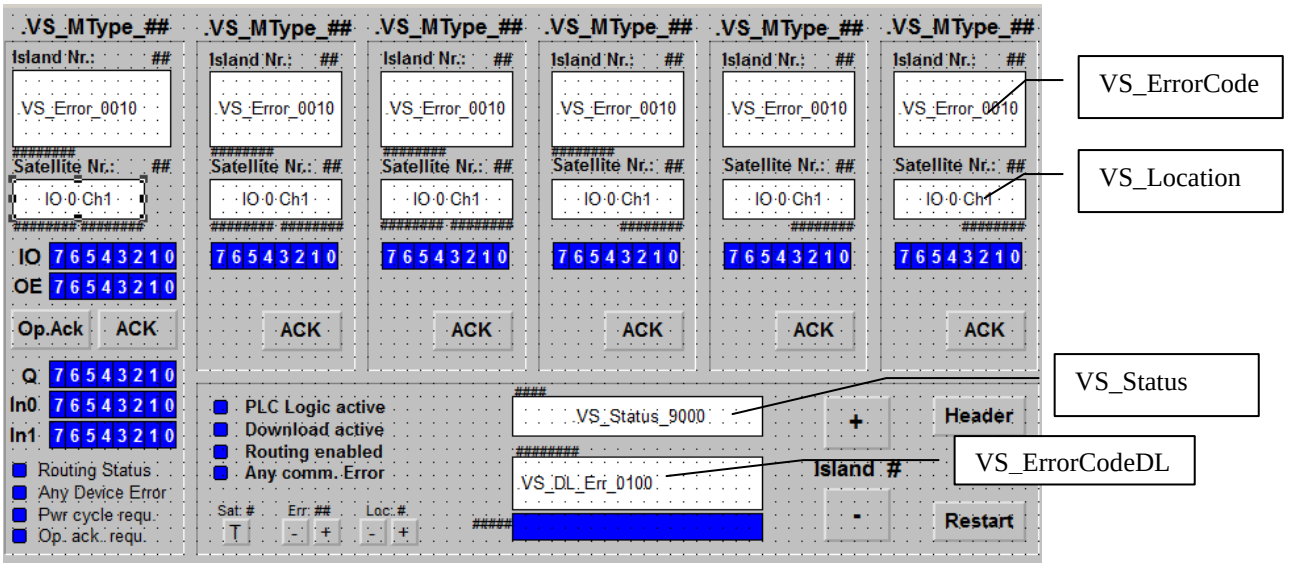
4. Import one of the PH_VSafe_xx.csv files to the RX3i target - variables. xx depends on the maximum number of islands you want to support. It is possible to upgrade the number islands at any time later. This step will add the diagnostic interface to QuickPanel View/Control for up to four safety islands.
5. Import the csv file VS_1.csv to the RX3i target - variables. This step will add the fieldbus interface for the first safety island. If you need more than one island, import also VS_2/3/4.csv
6. Include an unconditional call of VS_System in MAIN. Connect the “Enable” input to a condition that reflects the “OK” status of the fieldbus communication. If you are not sure, just connect an #ALW_ON.

5.3 Import HMI Panels and Scripts

If you work with separate PME projects, open the QuickPanel View/Control project now and open the drawer VersaSafe Integration again. Otherwise proceed directly.

1. Import the H_VSafe.csv file to the HMI_QP12 target - variables.
2. Drag VS_LIB from toolchest LIB folder to project folder Global Functions
3. Drag all items from toolchest folder MessageGrids to project folder Message Grids.
4. Drag all panels from toolchest folder Panels to project folder Graphical Panels.
5. Include panel VS_Diag into your navigation system. You may also want to rename it and adjust vertical size or position according existing conditions.
6. Enable language translation, add three languages English(default) German and Italian
7. Open Language.csv using MS excel. Select all rows, first 3 columns, “Copy”, open the language grid in PME, click with right mouse button into the grid and choose “Paste row(s)”

Note: Open the screen VS_Diag and check assignment of message grids according the following picture and update manually if it is not done automatically:



5.4 Create/Modify Safety Logic with VersaConf Safety

This step is only mentioned and briefly described here. For more information, see online help of VersaConf Safety.

Note about naming conventions:

The logic block created by VersaConf Safety has the name VS_call_x_<safety-logic-name>. Where x is the island number and <safety-logic-name> is the name of the VersaConf Safety project. Block names in ME are restricted to 31 characters total. That means, the name of the safety project is limited to 21 characters. Keep in mind also restrictions about usable characters for logic blocks in ME and the fact that ME is not case sensitive.

For each individual island:

- Create or modify safety logic.
- Open menu “Project” – “Check project”. When it is finished without error, you will find an XML file in the FileOutput folder of VersaConf Safety’s project folder.

5.5 Import XML file

If you work with separate PME projects, open the RX3i project now. Otherwise proceed directly. For each safety island do the following steps:

1. Click with right mouse button at Program Blocks / VSafe, and choose “Import Block from File …”.
2. Navigate to the VersaConf Safety project folder, FileOutput folder; open the XML file.
3. If a Variable Conflict dialog pops up, select “Use existing variable” and confirm. After some seconds a new ST block in VSafe will appear with the name VS_call_<Island number>_<SafeProjName>
4. Open the block VS_System and add the new ST block with instance name <SafeProjName>. Call it conditionally with an NO contact the input “Enable”.

5.6 Configure RX3i Logic

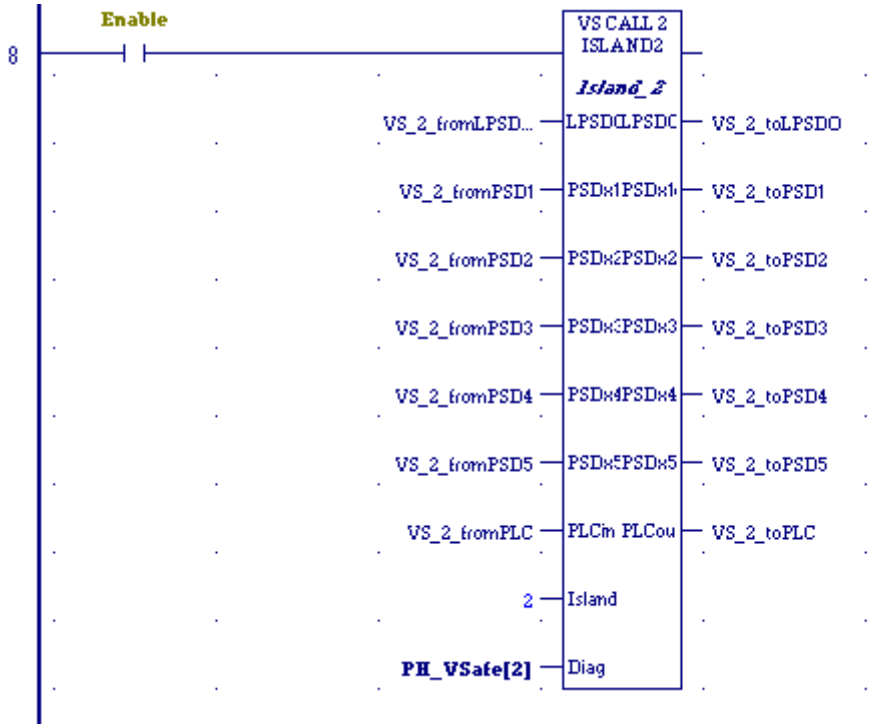
For each safety island block (VS_call_<Island number>_<SafeProjName>, see previous chapter) you have to attach appropriate parameters.

There are 6 input and 6 output parameters, which have to be connected via fieldbus to the safety modules. Depending on the used fieldbus, it can be by address based variables or by pure symbolic variables.

You can import the VS_1.csv file with referenced variables for convenience.

In addition there are some input and output parameter connected to internal GE IP Controller logic and a UDT structure for HMI communication.

Next picture shows an example for island # 2.



Input Parameter	Date Type	Signal
LPSDOin	WORD[24]	Input from LPSDO Module
PSD1in	WORD[4]	Input from PSD Module # 1
PSD2in	WORD[4]	Input from PSD Module # 2
PSD3in	WORD[4]	Input from PSD Module # 3
PSD4in	WORD[4]	Input from PSD Module # 4
PSD5in	WORD[4]	Input from PSD Module # 5
PLCin	WORD[4]	Input from GE IP Controller
Island	UINT	Island Nr
Diag	VS_PH_VSafe	PH_VSafe[Island]: Communication with HMI

Output Parameter	Date Type	Signal
LPSDOout	WORD[24]	Output to LPSDO Module
PSD1out	WORD[4]	Output to PSD Module # 1
PSD2out	WORD[4]	Output to PSD Module # 2
PSD3out	WORD[4]	Output to PSD Module # 3
PSD4out	WORD[4]	Output to PSD Module # 4
PSD5out	WORD[4]	Output to PSD Module # 5
PLCout	WORD[4]	Output to GE IP Controller

Mandatory parameters:

Island: Must be the number, which is defined in the VersaConf Safety tool and equal to DIP switch setting. Island is 1 based.

Diag: Attach the array member of PH_VSafe array with index = island number.

LPSDOin: 24 WORD array connected by fieldbus to the LPSDO module as input.

LPSDOout: 24 WORD arrays connected by fieldbus to the LPSDO module as output.

PSD1in: 4 WORD array connected by fieldbus to PSDx module #1 as input.

PSD1out: 4 WORD arrays connected by fieldbus to PSDx module #1 as output.

Optional parameters:

PSD2..5in: 4 WORD array connected by fieldbus to PSDx modules #2-5 as input.

PSD2..5out: 4 WORD arrays connected by fieldbus to PSDx modules #2-5 as output.

PLCin: 4 WORD array to allow the GE IP Controller to provide enable signals for the safety logic.

PLCout: 4 WORD array to allow the GE IP Controller access to signals of safety logic.

You can create appropriate arrays and assign the addresses you assigned during hardware configuration, or in case the fieldbus supports symbolic variables, you use the variables created during fieldbus configuration.

5.7 LPSDO and PSDx interface

User defined function blocks LPSDO & PSDx are provided as a part of integration tool chest for easy user interaction with the LPSDO & PSDx modules. These blocks are not mandatory for the Versasafe integration logic to work. They are useful in particular if status and confirmation signals shall be processed by PLC logic, not (only) by HMI.

If required, these blocks can be dragged to the application logic & used.

5.7.1 Configuration

1. Drag the LPSDO block from the Versasafe Integration tool chest to the logic.
2. Call the LPSDO UDFB in the logic and assign an instance name to it.
3. Pass the required island number to “IslandNr” input and pass the configured PLCIn parameter of VS_Call_xx block in VS_System for specified island number to “PLCIn” input.
4. All other bool inputs should be OFF and other inputs should be 0.
5. Assign coils with appropriate name to the outputs.
6. After the download of target and CPU placed in Run IO Enabled mode, make sure that VersaSafe integration logic is being called.

5.7.2 LPSDO

Input Parameter	Date Type	Description
IslandNr	UINT	Island number configured in LPSDO
OpAck	BOOL	Operator acknowledge for failsafe communication.
DevAck	BOOL	Error acknowledge for LPSDO.
Restart	BOOL	Restart download of safety logic from GE IP Controller to LPSDO. Rising edge triggered input
ConfirmDownload	BOOL	Confirm download of different logic to LPSDO. Rising edge triggered input. *Note: As a safety requirement, it is mandatory that "ConfirmDownload" input should not be turned ON programmatically and it has to be turned ON manually using a physical push button input or HMI push button input from user.*
AppAck	WORD	Application acknowledge bits 0 - 15.
EnableOut	BYTE	Enable output signals for LPSDO module.
PLCIn	WORD[4]	Configured PLCIn parameter of VS_Call_xx block in VS_System for specified island number.

Output Parameter	Date Type	Description
InvalidIsland	BOOL	Input island number is invalid
OutStatus	BYTE	LPSDO output status.
AppDiag	BYTE	Status of application diagnostic bits 0 – 7.
PLCLogicActive	BOOL	VersaSafe integration logic is executed
DownloadActive	BOOL	Download of safety logic from GE IP Controller to LPSDO is in progress
DownloadProgress	INT	Download progress percentage
DiffLogicDetected	BOOL	Safety logic in LPSDO is different from loaded project in GE IP Controller
RoutingEnabled	BOOL	Communication between VersaSafe modules is executed by GE IP controller
RoutingStatus	BOOL	Communication status between VersaSafe modules
CommErr	BOOL	Communication error is detected by the integration logic
PowerCycleReq	BOOL	Power cycle of LPSDO is required
AnyDevErr	BOOL	Any device error
OpAckReq	BOOL	Operator acknowledge is required
SysStatus	WORD	Island status. 9000H = Running, 9001H = No project, 9002H = Loading, 9003H = Stopped.
ModErrorCode	WORD	Module Error Code. Refer LPSDO module manual

5.7.3 PSDx

Input Parameter	Date Type	Description
IslandNr	UINT	Island number configured in LPSDO
SatelliteNr	UINT	Satellite number of the island
DevAck	BOOL	Error acknowledge for PSDx.
EnableOut	BYTE	Enable output signals for PSDO module. Applicable only for PSDO module. For PSDI module provide 0 to this input.
PLCIn	WORD[4]	Configured PLCIn parameter of VS_Call_xx block in VS_System for specified island number.

Output Parameter	Date Type	Description
InvalidIsland	BOOL	Input island number is invalid
InvalidSatellite	BOOL	Input satellite number is invalid
InOutStatus	BYTE	PSDI input / PSDO output status.
CommStatus	BYTE	Bit 0 - 3 refers to Module Communication Status. 0000 = OK 0001 = OK, but not yet started 0010 = DIP switch error 0011 = not connected 0100 = Invalid module type detected 1000 = not configured
ErrorCode	WORD	Module Error Code. Refer to the individual module manual

5.7.4 Operation

Steps to download safety logic from RX3i Controller to Safety logic module (LPSDO) using 'LPSDO' UDFB.

Note: These steps are not mandatory if HMI/View is used as mentioned in above sections.

1. The "PLCLogicActive" output should be ON. If it is OFF then either the VersaSafe integration steps is not followed correctly or integration logic is not called.

2. Once the "PLCLogicActive" is ON, the "DiffLogicDetected" output will be ON if the safety logic in RX3i Controller is different from safety logic in LPSDO module.

3. If "DiffLogicDetected" output is ON, turn ON the "ConfirmDownload" input for one scan so that download starts and the "DownloadActive" will be ON and the "DownloadProgress" gives the progress percentage of the download.

Note: As a safety requirement, it is mandatory that "ConfirmDownload" input should not be turned ON programmatically and it has to be turned ON manually using a physical push button input or HMI push button input from user.

4. After the completion of download, if the "OpAckReq" output in ON then turn ON the "OpAck" input till the "OpAckReq" output turns OFF.

5. Now the "SysStatus" output should be 9000H, "RoutingEnabled" & "RoutingStatus" outputs should be ON which indicates that the safety logic of that corresponding island is running and no errors are present. If not, just turn ON "Restart" input for one scan.

6. If the “OpAckReq” output in ON then turn ON the “OpAck” input till the “OpAckReq” output turns OFF.

7. Even now if any of “RoutingEnabled” & “RoutingStatus” outputs is OFF then check for any error output being set in LPSDO block outputs and check the individual satellite (PSDO/PSDI) status using PSDx block.

5.8 Download Targets and run Application

Now you can validate, download and start the targets.

5.9 Modification cycle

If the safety engineer has decided to modify the safety logic and created a new XML file, the XML file must be imported again. If the number of satellites has changed, you may need also to update the parameters.

If the number of islands has been increased, check the following items:

- The array size of PH_VSafe must be at least number of islands plus two.
- The array size of H_VSafe must be at least number of islands plus one.
- If you increase the array size of PH_VSafe, make sure all elements have the publish property equal “External”

If you work with separate PME projects, open the RX3i project now.

1. Click with right mouse button at Program Blocks / VSafe, and choose “Import Block from File …”.
2. Navigate to the VersaConf Safety project folder, FileOutput folder; open the XML file.
3. If a Variable Conflict dialog pops up, select “Use existing variable” and confirm. After some seconds the ST block with the name VS_call_<Island number>_<SafeProjName> is updated.

Typically you will be able to do a run-mode-store now to update the RX3i logic.

But this will not automatically invoke the updated safety logic. To trigger this you have the following options

- Stop/start (or power cycle) the RX3i
- Power cycle the remote station, where the LPSDO is part of
- Press restart on the HMI screen

In all cases, the new safety logic is initialized in RX3i memory, and is compared with the actual logic in the LPSDO. As we have modified the logic, a difference is found and a dialog pops up at the HMI, to show some relevant data of the project loaded in the LPSDO versus the new actual updated project. The operator must explicitly confirm that he wants to update the safety logic. This is part of the safety policy.

Additionally the GE IP Controller programmer (and the safety engineer) can look at any time into the ST block. There is a comprehensive comment section showing all relevant parameters of the actual safety logic (like time of last change, version etc).

Example:

```
// ================================================
// ST init block for VersaSafe
// PACSystem output format V 1.0
// Island: 2
// ================================================
//
// ==================
// Project Information
```

```
// ===================
// Application Name:                        VersaConf Safety 2.7
// Build Number:                            374
// Project Developer (Windows Login Name):  113004127
//
// =======
// Project
// =======
//
// Project (Program and Device Parametrization)
// --------------------------------------------
// Project Name:               AckTestBig
// Path to Project:            D:\Documents and Settings\113004127\My
Documents\AppProj\Applied Solution\VersaSafe\SafeConf
// Last changed:               28.03.2011    11:34:27
// Project CRC:                E0B9B5A6
//
// Archival Storage (Project and Documentation)
// --------------------------------------------
// Project Printed:            No
// Project Archived:           No
//
// =================
// Operating Company
// =================
//
// Address of Application Location
// -------------------------------
// Same as Operating Company:  No
//
// ======
// Checks
// ======
//
// Wiring
// ------
// Input Signals:              Not checked
// Output Signals:             Not checked
//
// Timing
// ------
// Output Signals:             Not checked
//
// Devices
// -------
// Compliancy:                 Not checked
// Device Parameters:          Not checked
//
// =======
// History
// =======
//
// Previous Project
// ----------------
// Predecessor exists?:        No
//
// ===========
// Project CRC
// ===========
//
// CRCs
// ----
// Project Header CRC:         90D01AD7
// Logical Block CRC:          F75C11D3
// Address Block CRC:          0D27D1B3
// Project Header Time Stamp:  28.03.2011    11:34:27
```

6 *Operating the VersaSafe HMI*

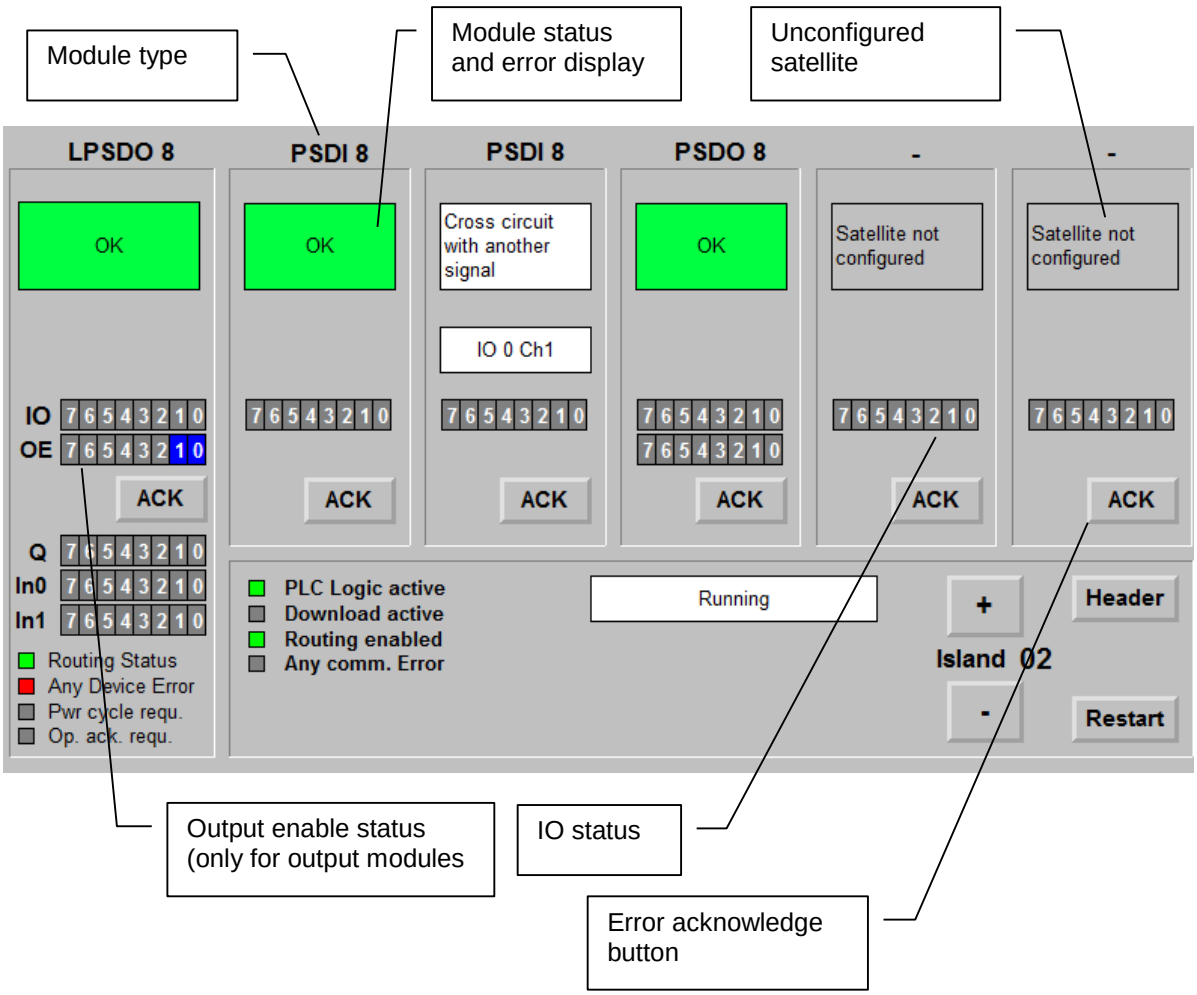
VersaSafe modules do not have any user operational controls and they have only a few LEDs to indicate the current state. Moreover they are often hidden somewhere in a cabinet.

A convenient tool to watch the status and operate the modules is the HMI screen which is included in the integration package.

It shows the status of the modules itself, of all physical IO, and of GE IP Controller interface signals.

In case of any safety event it will show a text message to indicate the location and the cause of the event.

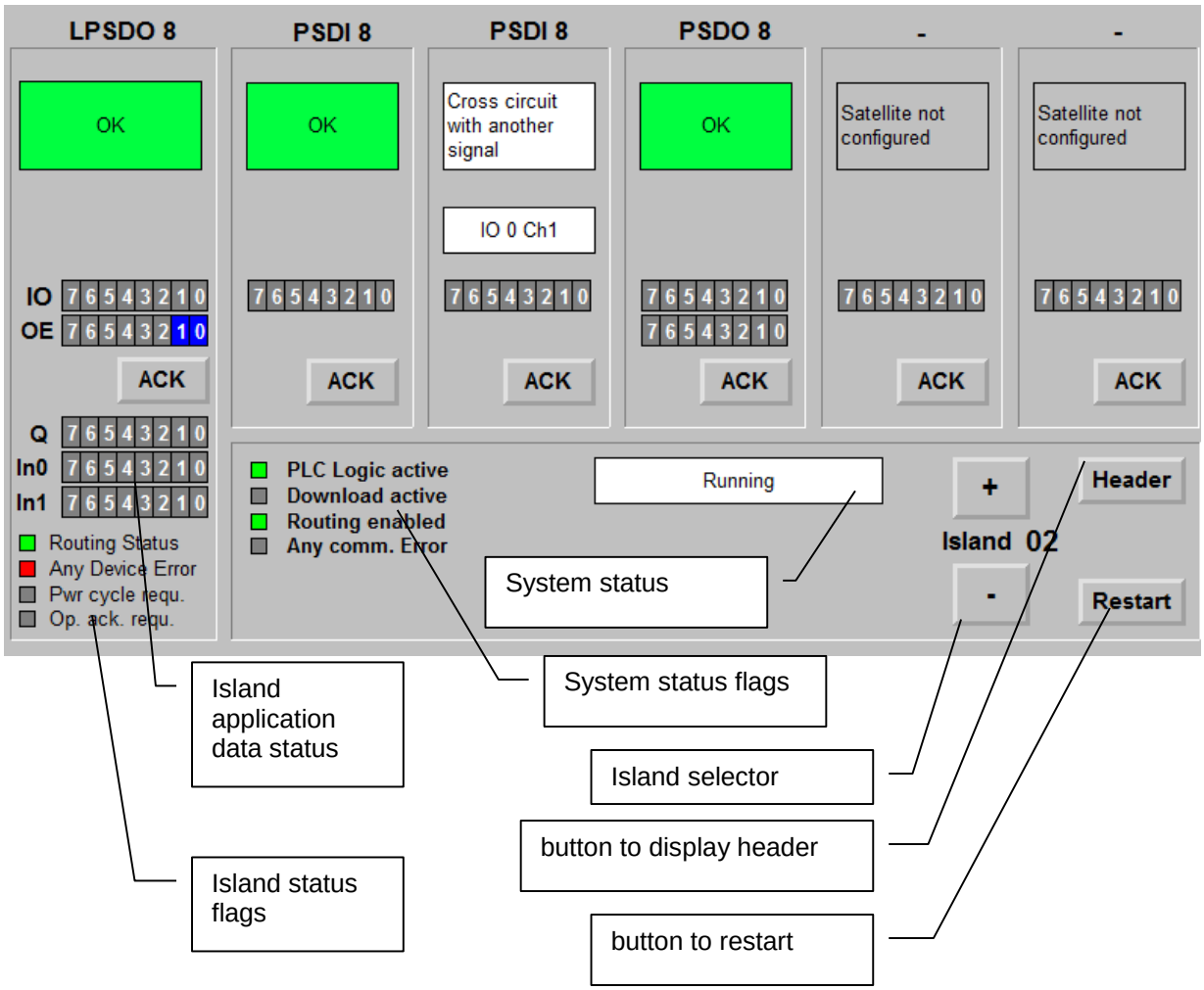
VersaSafe status screen, elements for module status:



For each module we have:

- Module type display (LPSDO, PSDI, PSDO)
- Module status display (configured, communicating, safety errors: text and location)
- IO status display (physical IO status)
- Output enable status display (only for LPSDO and PSDO)
- Error acknowledge button to confirm any safety event

VersaSafe status screen, elements for island status:



7 VersaSafe general Reference

Module Type IDs:

Module ID (hex)	Module ID (dec)	Module	Length of I-par block (Byte)
0x10	16	PSDI	26
0x20	32	PSDO	32
0x30	48	PSDOR	20
0x40	64	PSDO 4/4	20
0x50	80	LPSDO	32

8 *VersaSafe - GE IP Controller Logic Reference*

The VersaSafe application logic is designed to support the following data exchanges:

- Download compiled safety logic to the LPSDO
- Cyclic data exchange between LPSDO and safety IO modules
- Data exchange between GE IP Controller application logic and safety logic
- Data exchange between VersaSafe system and an HMI for diagnostic and user acknowledge purpose.

8.1 Data Exchange VersaSafe – GE IP Controller

The GE IP Controller application shall never write directly into VersaSafe IO data (see IO Data). There is a very high probability that in this case the safety goes into a safe state, switching off all outputs.

Instead the GE IP Controller application shall use the input parameter PLCin and the output parameter PLCout of the VersaSafe integration block to communicate with the safety logic. Both parameters are 4 word arrays.

The following tables show the assignment of signals.

Data from VersaSafe (read only for GE IP Controller):

Parameter	Device	Signal
PLCout[0].X[00-07]	LPSDO	Output 0 - 7
PLCout[0].X[08-15]	PSDx Satellite 1	In/Output 0 - 7
PLCout[1].X[00-07]	PSDx Satellite 2	In/Output 0 – 7
PLCout[1].X[08-15]	PSDx Satellite 3	In/Output 0 – 7
PLCout[2].X[00-07]	PSDx Satellite 4	In/Output 0 – 7
PLCout[2].X[08-15]	PSDx Satellite 5	In/Output 0 - 7
PLCout[3].X[00-07]	LPSDO	App-Diag 0 - 7

App-Diag Signals (8 bit) can be inserted in the safety logic, so that the GE IP Controller logic is aware of internal safety signals.

Data to VersaSafe:

Parameter	Device	Signal
PLCin[0].X[00-07]	LPSDO	Enable Output 0 - 7
PLCin[0].X[08-15]	PSDx Satellite 1	Enable Output 0 - 7
PLCin[1].X[00-07]	PSDx Satellite 2	Enable Output 0 – 7
PLCin[1].X[08-15]	PSDx Satellite 3	Enable Output 0 – 7
PLCin[2].X[00-07]	PSDx Satellite 4	Enable Output 0 – 7
PLCin[2].X[08-15]	PSDx Satellite 5	Enable Output 0 - 7
PLCin[3].X[00-07]	LPSDO	App-Ack 00 - 07
PLCin[3].X[08-15]	LPSDO	App-Ack 08 - 15

Enable Output signals do have only an effect for output modules (LPSDO, PSDO).

App-Ack signals (16 bit) can be used as additional enable signals within the safety logic.

8.2 IO Data

VersaSafe Modules represent an analog IO module within the given fieldbus. They can have either 4 or 16 or 24 words of input and output. The input size is always equal to the output size.

Do not use this data directly, it is only shown for reference here. Use the GE IP Controller interface instead.

The logic module (referred to as “LPSDO”) has 16 or 24 words of IO, depending on DIP switch setting.

All IO modules (referred to as PSDI and PSDO) have 4 words of IO.

The following tables show the usage of the 4 words of IO modules and the first 4 words of an LPSDO. Further words of the LPSDO are used for data exchange between IO and logic module or for download of safety logic to the logic module, depending on the state of the system. For more information see chapter “Safety Bridge System” of module manuals.

VersaSafe is a big endian system, while PACSystem is a little endian system, so care must be taken when accessing bytes.

Input Data, big endian ordered. The second column shows the byte # for a little endian (“Intel”) system.

Byte #	#	LPSDO	PSDI	PSDO
0	1	Dev-Diag (hi)	Dev-Diag (hi)	Dev-Diag (hi)
1	0	Dev-Diag (lo)	Dev-Diag (lo)	Dev-Diag (lo)
2	3	App-Diag	Input-Data	Protocol
3	2	Output-Data	Protocol	Protocol
4	5	Comm.-Protocol	Protocol	Protocol
5	4	Comm.-Protocol	Protocol	Protocol
6	7	Comm.-Protocol	Protocol	Reserved
7	6	Comm.-Protocol	Reserved	Output-Data

Output Data, big endian ordered. The second column shows the byte # for a little endian (“Intel”) system.

Byte #	#	LPSDO	PSDI	PSDO
0	1	Dev-Ack	Dev-Diag (hi)	Dev-Diag (hi)
1	0	App-Ack	Dev-Diag (lo)	Dev-Diag (lo)
2	3	App-Ack	Protocol	Output-Data
3	2	Enable-Out	Protocol	Protocol
4	5	Comm.-Protocol	Protocol	Protocol
5	4	Comm.-Protocol	Protocol	Protocol
6	7	Comm.-Protocol	Reserved	Reserved
7	6	Comm.-Protocol	Reserved	Enable-Out

Explanation:

Item	Direction	Description
Dev-Diag	VS -> PLC	Device diagnostic data, see module manual
App-Diag	VS -> PLC	Application data generated by safety logic
Dev-Ack	PLC -> VS	Device acknowledge, see module manual
App-Ack	PLC -> VS	Application data from GE IP Controller to safety logic
Enable-Out	PLC -> VS	Enable output, used if individually enabled by HW configuration
Input-Data	VS -> PLC	Status data from safe inputs
Output-Data	VS -> PLC	Status data from safe outputs
Comm.-Prot.	Both	Short communication protocol
Protocol	Both	Safety Bridge routing protocol

8.3 UDT

UDT	Purpose
VS_Cfg	Compiled safety logic: header block, address block, logic block
VS_CfgLB	Logic block for VS_Cfg
VS_PH_VSafe	Communication object for HMI

8.4 Logic Blocks

Block	Type	Lang.	Purpose
VS_call_<Island number>_<SafeProjName>	UDFB	ST	Initialize compiled safety logic and call VS_Island, created as XML by VersaConf Safety
VS_Island	UDFB	LD	Safety island management block
VS_Download	UDFB	ST	Communicate with LPSDO
VS_CheckAddr	PB	LD	Verify correct DIP settings
VS_Data	PB	ST	Extract data for HMI and GE IP Controller
conv…..	PB	LD	Various auxiliary conversion subroutines

8.4.1 VS_call_<Island number>_<SafeProjName>

This ST block is created by VersaConf Safety as XML, and is imported into PME. Never change this block in any way. The contents of the block are:

- Safety project documentation as comments
- Initialisation of compiled safety logic
- Call an instance of VS_Island

Input Parameters:

Parameter	Type	
LPSDOin	BYTE[48]	24 Words input from LPSDO module (fieldbus)
PSDx1in	BYTE[4]	2 Words input from PSDx satellite 1 (fieldbus)
PSDx2in	BYTE[4]	2 Words input from PSDx satellite 2 (fieldbus)
PSDx3in	BYTE[4]	2 Words input from PSDx satellite 3 (fieldbus)
PSDx4in	BYTE[4]	2 Words input from PSDx satellite 4 (fieldbus)
PSDx5in	BYTE[4]	2 Words input from PSDx satellite 5 (fieldbus)
PLCin	WORD[4]	4 Words input from GE IP Controller application
Island	INT	Number of safety island (1...31)
Diag	UDT	Diagnostic data, shall be published external for HMI

Output Parameters:

Parameter	Type	
LPSDOout	BYTE[48]	24 Words output to LPSDO module (fieldbus)
PSDx1out	BYTE[4]	2 Words output to PSDx satellite 1 (fieldbus)
PSDx2out	BYTE[4]	2 Words output to PSDx satellite 2 (fieldbus)
PSDx3out	BYTE[4]	2 Words output to PSDx satellite 3 (fieldbus)
PSDx4out	BYTE[4]	2 Words output to PSDx satellite 4 (fieldbus)
PSDx5out	BYTE[4]	2 Words output to PSDx satellite 5 (fieldbus)
PLCout	WORD[4]	4 Words output to GE IP Controller application

All parameters are passed to VS_Island. Additionally the UDT based structure “Conf” which contains the compiled safety logic, is passed to VS_Island.

8.4.2 VS_Island

The block VS_Island manages one island. Each island needs its own instance. It is automatically created within VS_call_<Island number>_<SafeProjName>.

Functions of this block:

- insert island number in compiled logic (required as part of the safety policy)
- check module address (DIP setting) for each module
- Call VS_Download to communicate with LPSDO
- Map GE IP Controller and HMI data to VersaSafe data
- Move data from/to LPSDO <-> PSD

Input Parameters:

Parameter	Type	
LPSDOin	BYTE[48]	24 Words input from LPSDO module (fieldbus)
PSDx1in	BYTE[4]	2 Words input from PSDx satellite 1 (fieldbus)
PSDx2in	BYTE[4]	2 Words input from PSDx satellite 2 (fieldbus)
PSDx3in	BYTE[4]	2 Words input from PSDx satellite 3 (fieldbus)
PSDx4in	BYTE[4]	2 Words input from PSDx satellite 4 (fieldbus)
PSDx5in	BYTE[4]	2 Words input from PSDx satellite 5 (fieldbus)
PLCin	WORD[4]	4 Words input from GE IP Controller application
Island	INT	Number of safety island (1...31)
Diag	UDT	Diagnostic data, shall be published external for HMI
Conf	UDT	Compiled safety logic

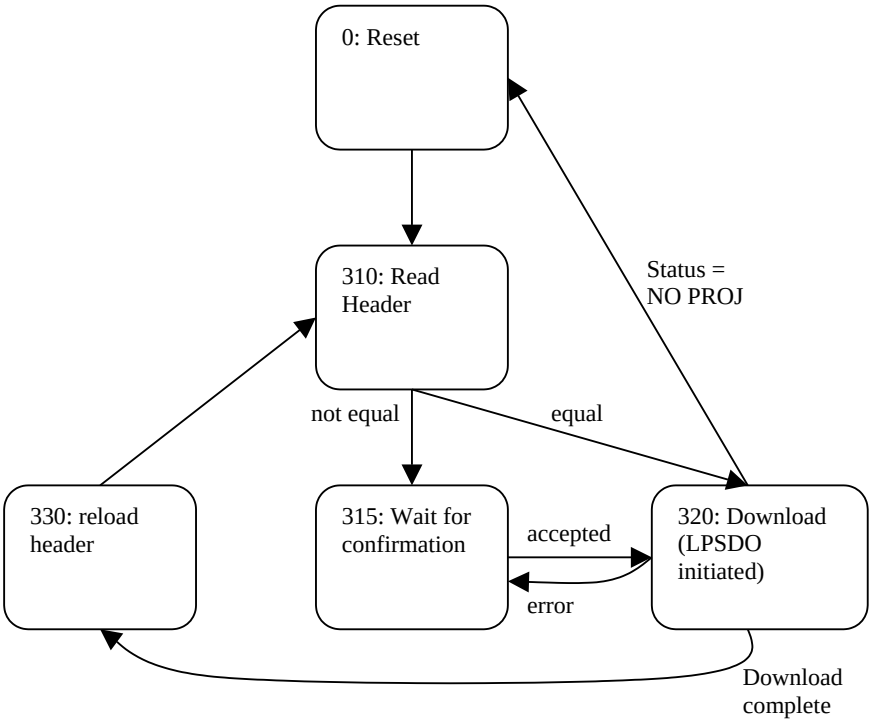
Output Parameters:

Parameter	Type	
LPSDOout	BYTE[48]	24 Words output to LPSDO module (fieldbus)
PSDx1out	BYTE[4]	2 Words output to PSDx satellite 1 (fieldbus)
PSDx2out	BYTE[4]	2 Words output to PSDx satellite 2 (fieldbus)
PSDx3out	BYTE[4]	2 Words output to PSDx satellite 3 (fieldbus)
PSDx4out	BYTE[4]	2 Words output to PSDx satellite 4 (fieldbus)
PSDx5out	BYTE[4]	2 Words output to PSDx satellite 5 (fieldbus)
PLCout	WORD[4]	4 Words output to GE IP Controller application

8.4.3 VS_Download

This block does the communication with LPSDO for download of compiled logic and LPSDO status.

State Machine:



Pseudo Code for extracting the module ID

```
 (*
It is assumed the logic block consists of a zero-based DW array
LogicBlockDW
*)
ByteOffset  := LogicBlockDW[2].W0 + LogicBlockDW[2].W1 + 13 ;
DWoffset    := ByteOffset / 4 ;
ByteNr      := ByteOffset Mod 4 ;
ModuleCount := BYTE_TO_INT (LogicBlockDW[DWoffset].B[ByteNr]) ;
ByteOffset  := ByteOffset + 4 ;
For i := 0 To ModuleCount-1 Do
       DWoffset := ByteOffset / 4 ;
       ByteNr := ByteOffset Mod 4 ;
       ModuleID[i] := BYTE_TO_INT (LogicBlockDW[DWoffset].B[ByteNr]) ;
       Case ModuleID[i] Of
              16:                          (* PSDI *)
                     ByteOffset := ByteOffset + 16;
              32,80:                 (* PSDO, LPSDO *)
                     ByteOffset := ByteOffset + 32;
              48,64:                 (* PSDOR, PSDO 4/4 *)
                     ByteOffset := ByteOffset + 20;
       End_Case;
End_For;
```

8.4.4 Conversion Subroutines

PB	Purpose
conv10DW2Bytes	converts 10 DWORDS to 40 byte
convByte2Int	convert one byte to an integer
convBytes2DW	converts 4 Bytes to a DWORD
convDW2Byte	extracts one byte from a DWORD
convDW2Ws	converts one DWORD to two WORDs

9 *VersaSafe HMI Reference*

9.1 Data Exchange: GE IP Controller – HMI

Data exchange between GE IP Controller and HMI is performed by arrays of structures.

On GE IP Controller side the structure is implemented as UDT. The variable name is PH_VSafe. Array member index zero is unused. Island 1 uses array member index 1 and so on. All variables (except unused index 0) must have their Publish property equal External, to be able to communicate by symbolic SRTP.

On HMI side it is a corresponding toolchest structure. The variable name is H_VSafe. Array member index zero is used as indirect variable to animate the screen elements. Higher indices are connected to the corresponding GE IP Controller variables as GE IP Controller Access variables.

Members of communication structure:

Element	PLC Type	HMI Type	
ComDiag	WORD[6]	DINT[6]	Island communication Status
Ack	DWORD	DINT	Application data from Island
HeaderLPSDO	DWORD[10]	DINT[10]	Project Header actually stored in LPSDO
HeaderProj	DWORD[10]	DINT[10]	Project Header from compiled safety logic
Data	DWORD[6]	DINT[6]	Data from modules (1 DWORD per Sat.)
Status	DWORD[6]	DINT[6]	Status from modules (1 DWORD per Sat.)
DevAck	BOOL[16]	BOOL[16]	Device acknowledge signals

ComDiag:

Element	Type	Signal	
ComDiag[0].X[0]	BOOL	PLC Logic Active	VersaSafe integration logic is executed
ComDiag[0].X[1]	BOOL	Download active	Download of compiled safety logic from GE IP Controller to LPSDO is in progress
ComDiag[0].X[2]	BOOL	Different logic detected	Safety logic in LPSDO is different from loaded project in GE IP Controller
ComDiag[0].X[3]	BOOL	Routing Enabled	Communication between VersaSafe modules is executed by the GE IP Controller.
ComDiag[0].X[4]	BOOL	Comm. error	Any error detected by the integration logic
ComDiag[1]	WORD	LPSDO Byte[4]	LPSDO communication object or FF=error
ComDiag[2]	WORD	LPSDO Byte[5]	LPSDO status
ComDiag[3]	WORD	LPSDO Byte[6]	LPSDO status
ComDiag[4]	WORD	LPSDO Byte[7]	LPSDO status
ComDiag[5]	INT	Progress	Download progress

Bits 0-7 of ComDiag[0] are dedicated to show the status of GE IP Controller integration logic.

The rest of ComDiag reflects the status of the LPSDO, once the integration logic is executing and the LPSDO is communicating.

Status:

Element	Type	Signal	
Status[0].X[11]	BOOL	OAR	Operator Acknowledge Required
Status[0].X[12]	BOOL	PUR	Power Up Requested
Status[0].X[13]	BOOL	Error	Any Device Error
Status[0].X[15]	BOOL	COK	Communication OK
Status[i].X[00-07]	BOOL	Module Type	1 Byte
Status[i].X[16-27]	BOOL	Module error code	See individual module manual
Status[i].X[28-31]	BOOL	Module comm. status	0000 = OK 0001 = OK, but not yet started 0010 = DIP switch error 0011 = not connected 0100 = Invalid module type detected 1000 = not configured

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
Status				Module Error Code												Unused								Module Type								

Data:

Element	Type	Signal	
Data[i].X[00-15]	BOOL	Error Code	See individual module manual
Data[i].X[16-23]	BOOL	Output Enable	Only LPSDO and PSDO.
Data[i].X[24-31]	BOOL	IO data	

DevAck:

Element	Description
DevAck[0]	Error acknowledge for LPSDO
DevAck[1..5]	Error acknowledge for Satellites 1-5
DevAck[6]	Reserved
DevAck[7]	Operator acknowledge for failsafe communication
DevAck[8]	Restart download of safety logic from GE IP Controller to LPSDO
DevAck[9]	Confirm download of different logic
DevAck[10..15]	Reserved

9.2 Screens

9.2.1 Main VersaSafe Diagnostic Screen

Element	Type	Visibility	Animation
Module Header	Text	-	Module Type
Error Header 1 (LPSDO)	Message Anim.	L_VS_PSDxValid[S]	Data[0].X[14]
Error Header 1 (PSDx)	Message Anim.	L_VS_PSDxValid[S]	Data[S].X[15]
Island Nr. (LPSDO)	Text	Data[0].X[14]	(Data[S] BAND 248) / 8
Island Nr. (PSDx)	Text	Data[S].X[14] AND NOT Data[S].X[15]	(Data[S] BAND 248) / 8
Error Code Text	Message Grid	-	L_VS_ErrCode[S]
Error Header 2	Text	L_VS_PSDxValid[S]	Data[0].X[14]
Satellite Nr (LPSDO)	Text	Data[0].X[14]	Data[0] BAND 7
Satellite Nr (PSDx)	Text	Data[S].X[14] AND NOT Data[S].X[15]	Data[S] BAND 7
Error Location Text	Message Grid	-	L_VS_ErrLoc[S]
IO Status	Rectangle[8]	-	Data[S].X[24-31]
Enable Output	Rectangle[8]	-	Data[S].X[16-23]
App Diag Data	Rectangle[8]	-	Ack.X[00-07]
App Ack Data	Rectangle[16]	-	Ack.X[16-31]
Ack Error	Button	-	DevAck[S]
Op Ack	Button	Data[0].X[11]	DevAck[07]

9.3 Scripts

Global Functions script: VS_LIB

Sub	comment
DWORD2STRING (dw, s)	converts a DWORD to a string
ErrorDecodePSDx (Status, ErrLoc, ErrCode)	decodes error codes from PSDIx
ErrorDecodeLPSDO (Status, ErrLoc, ErrCode)	decodes error codes from LPSDO

9.4 Structures

See Data Exchange VersaSafe – GE IP Controller

10 *VersaSafe Performance*

The time to exchange process data between the controller and the devices of VersaSafe islands are as follows:

10.1 Transit Time from RX3i Controller to LPSDO

The time to transfer data from RX3i Controller to LPSDO output is calculated according to the below formula:

$$t_{LPSDO} = \{(t_{Controller} + t_{Profibus} + t_{NIU}) \times 1.5\} + t_{SafetyLogic}$$

where,

t_{LPSDO}	*Transit time from RX3i controller to LPSDO output in ms*
$t_{Controller}$	*GE IP Controller sweep time in ms*
$t_{Profibus}$	*Profibus cycle time in ms*
t_{NIU}	*NIU reaction time in ms*
$t_{SafetyLogic}$	*Safety logic scan time: $t_{SafetyLogic}$ = 8 ms (max)*

$t_{NIU} = 2 \times t_t + 2 \times t_C$

t_t	*Station transmission time in ms*
t_C	*NIU Conversion time: t_C = 2 ms*

$t_t = [1.15 \times 13 \times (8+n) + 3a] \times t_b + t_s + 2t_p$

n	*Number of user data bytes*
a	*Number of modules on NIU*
t_b	*Bit duration: t_b = 0.002ms at 500 kbit/s*
t_s	*Software runtime: t_s = 0.7 ms*
t_p	*Runtime on cable: t_p = 0.016 ms/km*

10.2 Transit Time from PSDI to RX3i Controller

The time to transfer data from PSDI input to RX3i Controller when the safety input transitions from ON to OFF is calculated according to the below formula:

$$t_{PSDI1\text{-}0} = \{(t_{Controller} + t_{Profibus} + t_{NIU}) \times 1.5\} + t_{Filter}$$

where,

$t_{PSDI1\text{-}0}$	*Transit time from PSDI input (1 to 0) to RX3i controller in ms*
$t_{Controller}$	*GE IP Controller sweep time in ms*
$t_{Profibus}$	*Profibus cycle time in ms*
t_{NIU}	*NIU reaction time in ms: Refer Section 10.1*
t_{Filter}	*Input filter time (in ms) configured in VersaConf Safety tool*

The time to transfer data from PSDI input to RX3i Controller when the safety input transitions from OFF to ON is calculated according to the below formula:

$$t_{PSDI0\text{-}1} = \{(t_{Controller} + t_{Profibus} + t_{NIU}) \times 1.5\} + t_{Filter} + t_{SafetyTest}$$

where,

$t_{PSDI0\text{-}1}$	*Transit time from PSDI input (0 to 1) to RX3i controller in ms*
$t_{Controller}$	*GE IP Controller sweep time in ms*
$t_{Profibus}$	*Profibus cycle time in ms*
t_{NIU}	*NIU reaction time in ms: Refer Section 10.1*
t_{Filter}	*Input filter time (in ms) configured in VersaConf Safety tool*
$t_{SafetyTest}$	*Safety relevant test time in PSDI: $t_{SafetyTest}$ = 22 ms (max)*